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Boundary work in value co-creation practices: the mediating role of cognitive assistants

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Abstract

Purpose – How to improve healthcare for the ageing population is attracting academia attention. Emerging technologies (i.e. robots and intelligent agents) look relevant. This paper aims to analyze the role of cognitive assistants as boundary objects in value co-creation practices. We include the perceptions of the main actors – patients, (in)formal caregivers, healthcare professionals – for a fuller network perspective to understand the potential overlap between boundary work and value co-creation practices.

Design/methodology/approach – We adopted a grounded approach to gain a contextual understanding design to effectively interpret context and meanings related to human–robot interactions. The study context concerns 21 health solutions that had embedded the Watson cognitive platform and its adoption by the youngest cohort (50–64-year-olds) of the ageing population.

Findings – The cognitive assistant acts as a boundary object by bridging actors, resources and activities. It enacts the boundary work of actors (both ageing and professional, caregivers, families) consisting of four main actions (automated dialoguing, augmented sharing, connected learning and multilayered trusting) that elicit two ageing value co-creation practices: empowering ageing actors in medical care and engaging ageing actors in a healthy lifestyle.

Originality/value – We frame the role of cognitive assistants as boundary objects enabling the boundary work of ageing actors for value co-creation. A cognitive assistant is an "object of activity" that mediates in actors' boundary work by offering novel resource interfaces and widening resource access and resourceness. The boundary work of ageing actors lies in a smarter resource integration that yields broader applications for augmented agency.

Keywords Ageing population, Value co-creation, Boundary work, Boundary objects, Cognitive assistant

Paper type Research paper

Introduction

We are entering the Silver Economy: "the sum of all economic activity serving the needs of those aged 50 and over including both the products and services they purchase directly and the further economic activity this spending generates" (European Commission, 2018a). This is not a separate market segment but a cross-section cluster spanning the middle-aged (50–64 years), third age (65–74), fourth age (75–84) and the "oldest-old" (85+) (Klimczuk, 2015). With this whole so-called ageing (as opposed to "aged") – population expected to double by 2070 (European Commission, 2018b), severe, widespread implications loom for family structures and for sectors including labor and financial markets, and notably healthcare. Increasing longevity poses social challenges alongside commercial opportunities, to help citizens (Gerłowska *et al.*, 2018), by not only treating disease, but improving well-being (Odlum *et al.*, 2018).

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The World Health Organization is working on three areas: chronic disease prevention, accessible age-friendly primary healthcare and age-friendly environments (WHO, 2021).

How to improve healthcare for the ageing is attracting academia attention (Graffigna *et al.*, 2014; Huang and Yu, 2015). Scholars have investigated macroeconomic effects (Langhamrova *et al.*, 2018), especially of healthcare expenditure (Howdon and Rice, 2018), and implications for public policy intervention (Veenman, 2013). Service research on healthcare has addressed large-scale, social and technological innovation (e.g. e-health, telecare, independent living), which promises more efficient long-term care (Danahar and Gallan, 2016; Russo Spena and Mele, 2020). Emerging cognitive assistance technologies (i.e. robots and intelligent agents) look relevant (Kraus *et al.*, 2021), especially in the context of value co-creation (Čaić *et al.*, 2018). As Zeithaml *et al.* (2020) recognize, value is co-created during value co-creation practices. However there is no shared definition of "value co-creation practices". Consistent with a systemic and contextual view, a group of scholars sees value co-creation practices as sets of mental models, roles, interactions, actions and emotions through which actors make sense of and integrate resources (Wieland *et al.*, 2016; Taiminen *et al.*, 2018). In research focusing on healthcare, a practice approach examines what patients do when they co-create value and improve well-being (Mccoll-Kennedy *et al.*, 2017). Most studies focus on customer value co-creation as a "benefit realized from integration of resources through activities and interactions with collaborators in the customer's service network" (McColl-Kennedy *et al.*, 2012, p. 384). Other research suggests going beyond a strict customer focus to include multiple participants to catch which resources are available, when they are employed and how they are integrated (Sweeney *et al.*, 2015; Frow *et al.*, 2016). Among resources a valuable role is performed by technology and how to foster value co-creation practices in healthcare through technologies represents a key priority in service research (Kabadayi *et al.*, 2020; Ostrom *et al.*, 2021).

We build on this emerging literature to analyze the role of cognitive assistants – computers that help actors understand what is going on around them (Siddike *et al.*, 2018) – in the value co-creation (Güell *et al.*, 2020). Recent studies on cognitive technology assume that they break knowledge boundaries, facilitating knowledge sharing and the generation of new knowledge among a wider network of actors (Russo Spena *et al.*, 2019; Mele and Russo-Spena, 2019). Thus, we include the perceptions of the main actors – patients, (in)formal caregivers, healthcare professionals – for a fuller network perspective (Čaić *et al.*, 2018) to investigate how they negotiate and integrate new knowledge, artefacts and material arrangements.

Our research question asks: How do cognitive assistants act as boundary objects and affect actors' boundary work in value co-cocreation practices?

Our qualitative research approach serves to explicate complex issues and advance knowledge (Gummesson, 2017). The focus is on various embodiments of the cognitive assistant IBM Watson Health, an application for natural language processing, information retrieval, knowledge representation, automated reasoning and automatic learning technologies (Russo Spena *et al.*, 2019). We study health implications for the youngest "ageing" cohort: 50–64-year-olds, who consider themselves still middle-aged (Klimczuk, 2015) or of "prospective age" as they expect many years of healthier and more productive life (Sanderson and Scherbov, 2010). The Silver Economy, after all, embraces not only older people (65+) but many other active people with distinct needs (Kubiak, 2016). No service research studies to date address this segment's needs specifically. Yet besides beckoning researchers as a gap, the segment is of interest because it extends the traditional conception of age, and because of its purchasing power, high living standards and education. While the Silver Economy includes all 50–64 years old, we focus on those who are receiving healthcare, though also nonetheless considering healthy individuals who simply want to maintain a healthy lifestyle.

Our main contribution lies in framing the role of cognitive assistants as boundary objects enabling the boundary work of actors for value co-creation. A cognitive assistant is an "object of activity" (Macpherson *et al.*, 2006) that mediates in actors' boundary work by offering novel resource interfaces (Fremont *et al.*, 2019) and widening resource access and resourceness (Vargo and Lusch, 2014). Four main mediated technology actions distinguish this work: database dialoguing, augmented sharing, connected learning and multilayered trusting. The analysis of the actors' boundary work allows us to disentangle the process of value creation between actors within the healthcare context. Two enhanced value co-creation practices emerge: empowering actors in medical care and engaging actors in a healthy lifestyle. The boundary work of actors lies in a smarter resource integration that yields broader applications for augmented agency (Mele *et al.*, 2021).

The article proceeds as follows. First, we review the literature on cognitive assistance technologies in healthcare, technology as boundary object and the role of technologies and value co-creation practices. The methodology and then findings follow. Next, we discuss sequentially the main theoretical contributions, practitioner implications and avenues for further research.

Literature review

Cognitive assistance technologies in healthcare

Our main label "cognitive assistant" (though we also say, e.g. "assistive/assistant robot" and "virtual assistant") identifies "cognition-as-a-service" (Spohrer and Banavar, 2015, p. 71); cognitive technologies/systems based on artificial intelligence and signal processing, capable of simulating human thought in complex situations where answers may be ambiguous and uncertain.

How novel technology, such as assistive/assistant robots, impacts healthcare is an emerging theme in service research (Berry *et al.*, 2019). Innovative solutions for older people feature under three main heads: (1) task effectiveness, (2) decision process and (3) social support.

First, one family of studies have recognized the benefits of cognitive computing – hardware or software solutions that mimic human intelligence capabilities (Russo Spena *et al.*, 2019). Indeed, using algorithms, cognitive agents can find working preferences, suggest collaborations and upskill actors (patients and others) (Peine and Moors, 2015; Mele *et al.*, 2021). Thus, assistant robots help improve task effectiveness for consumers alongside operational efficiencies for providers (Taiminen *et al.*, 2018; Kaartemo and Helkkula, 2018).

Second, assistant robots support decision processes by analyzing copious data within minutes, integrating internal and external information, spotting patterns and relating them to customer profiles (Wirtz *et al.*, 2021). Thanks to the computer power underlying, for example, image analysis software, cognitive assistants can support the decision processes of both doctors in their diagnostic and care tasks (Wirtz *et al.*, 2018), and patients, by providing cognitive and memory assistance (Čaić *et al.*, 2018).

Third, assistive robots can provide social support (Odekerken-Schröder *et al.*, 2020). Scholars argue that using more socially assistive technologies lets care providers improve older people's wellbeing (Khaksar *et al.*, 2016), by empowering patients and redefining customer-centeredness (Patrício *et al.*, 2019; Kraus *et al.*, 2021).

Although care needs are recognized as urgent, service literature has maintained a narrow focus within illness or vulnerability conditions (Kabadayi *et al.*, 2020) prioritizing segments traditionally thought of as old rather than the full 50+ ageing segment envisaged by the Silver Economy. Assistive health and care can engage technology more closely with the lives and practices of others, notably younger cohorts with different conditions and abilities, and with their respective caregivers and doctors. As Daskalopoulou *et al.* (2019) have recently noted, cognitive technology offers technology-mediated healthcare services two benefits:

recognizing sense-giving opportunities and creating templates of action for providers and customers. However, science is only beginning to appreciate precisely how cognitive technologies can perform such a sense-giving role. We argue that intelligent devices matter in assisting healthcare provision, and therefore merit more attention in service research. Previous technology-based health studies have concentrated more on the functions and tasks these technologies support, marginalizing their nature as boundary objects.

Technology as a boundary object

Since its introduction (Star, 1989, 2010), the concept of boundary objects has served to capture possible ways users work cooperatively when lacking a consensus. Wenger (2000) identifies three types of boundary objects: artefacts, discourses and processes. Artefacts comprise standardized forms, methods, objects, models and maps; discourses represent a common language whereby people can communicate and negotiate meanings across boundaries; and processes include explicit organizational routines and procedures.

Whatever the type (whether abstract or concrete), boundary objects are "a means of translation" (Bowker and Star, 2000, p. 297), but being plastic, stay both adaptable to local needs and robust enough to keep a common identity across uses. Studies on boundary objects look at the problems of knowledge sharing between actors who try to coordinate and align their perspectives (Klimbe *et al.*, 2010). How groups perceive the boundary objects affects the interaction process by forming novel resource interfaces (Fremont *et al.*, 2019). By building on activity theory (Engeström, 2001) and boundary objects (Carlile, 2004), Macpherson *et al.* (2006) and Nicolini *et al.* (2012) address mediating devices as "objects of activities", promoting collective understanding sustained by social interactions. Mele *et al.* (2019) discuss boundary objects as bridge-makers that connect actors, fostering integration and sensemaking. They are facilitators of conversation and coordination or representations in the making. They can connect communities, by allowing groups to collaborate, thus becoming means of representing, learning about and transforming knowledge at a boundary.

Recent works address the potential role of technology as boundary objects, or as "boundary technology" due to unique capability (processing, learning and adoption) to help communities learn about their differences and dependences (Krafft *et al.*, 2020). Kot and Leszczynski (2020) discuss business virtual assistants (BVAs) as boundary objects for performing boundary tasks in business interactions, to help standardize activities and resources: BVAs are resources letting people interact (in)directly across different organizations "on the periphery of each actor's boundaries" (Kot and Leszczyński, 2020, p. 1157). Once interpreted by actors, they influence, stimulate or facilitate communication and coordination by eliminating ambiguities and confusion, but can also serve as valuable assets in linking resources and activities (Corsaro, 2018).

Overall, claims that boundary objects serve as catalysts for value co-creation (Jefferies *et al.*, 2019) and bridge-makers between actors, thereby fostering integration, learning and coordination in their value practices (Mele *et al.*, 2019; Kot and Leszczyński, 2020), seem relevant to our study.

Technologies and value co-creation practices in healthcare

Service scholars address value co-creation using a practice-based approach (McColl-Kennedy *et al.*, 2015), where social reality is (re)produced through everyday actions (Gherardi, 2016), and the social world fundamentally comprises practices, namely the unfolding of behaviors that include activities, performances and representations (Warde, 2005). Social practices are units of value creation (Schau *et al.*, 2009). Value co-creation practices can be framed as a collective, dynamic and evolving set of shared schemas, performative actions and emotions, through which actors exchange, make sense of and integrate resources (Wieland *et al.*, 2016; Taiminen *et al.*, 2018).

A range of technological solutions (from online consulting to IoT) seem to affect activities in value co-creation practices. Osei-Frimpong *et al.* (2018) illuminate co-creation practices resulting from online access that "empowers patients to be informed" and to "play an active role in clinical encounters with the doctor" (p. 14). They suggest that pre-encounter information searching helps shape provider–patient interactions, enhance providers' patient orientation and involve patients more in decision-making.

Taking as focal actor the elderly person, Čaić *et al.* (2018) analyze the role of service robots performing in human-like ways as actors in value co-creation/co-destruction practices. They identify three health-supporting functions: social contact, cognitive support and safeguarding. Although not identifying specific value co-creation practices, they highlight technological activities influencing co-creation through greater ability to connect, more access to information and improved ability to monitor.

Widening the lens from patient–robot interactions to the larger service ecosystem, Mele and Russo-Spena (2019) address how practices evolve in the healthcare ecosystem as the Internet of Everything (IoE) enables information accessibility and resourceness, with implications for resource integration. Two main co-creation practices emerge: networking and knowing. By enabling networking practices, the IoE can bridge the provider–patient gap and connect multiple co-creating actors. Knowing practices emerge from entangled forms of knowledge and let actors modify the status quo of co-creating.

In a recent study Mele *et al.* (2021) show how AI-driven nudged choices prompt value co-creation. Smart nudging concerns the use of cognitive technologies to affect people's behavior predictably, without limiting their options or altering their economic incentives. Several choice architectures and nudges affect value co-creation, by (1) widening resource accessibility, (2) extending engagement or (3) augmenting human actors' agency. Although cognitive technologies are unlikely to engender smart outcomes alone, they enable designs of conditions and contexts that promote smart behaviors, by amplifying capacities for self-understanding, control and action.

The debate about smart technologies and value co-creation is still emerging (Kabadayi *et al.*, 2020; Mele *et al.*, 2021). Research on service robots and cognitive technology could offer greater insights as these perform wide-ranging tasks in diverse settings (Lu *et al.*, 2020), besides offering new ways to deliver and experience healthcare services (Odekerken-Schröder *et al.*, 2020).

Value co-creation and boundary work: a missing link

By adopting a view of cognitive assistants as boundary objects, we question how such an object can affect value co-creation practices in terms of boundary work. The concept of "boundary work" acknowledges that actors involved in technical decisions broker knowledge (Callon, 1998). Boundary work eases tensions between actors (such as doctors and patients) lacking shared knowledge systems. This suggests that mutual understanding is attainable while preserving the boundaries necessary to clearly delineate each role. Langley *et al.* (2019) conceptualize boundary work as affecting "social, symbolic, material and temporal boundaries, involving groups, types of occupations and organizations" (p. 705). In this perspective, a recent work on boundary work investigates how actors, practices and values change within a context and define new socio-technical arrangements (Jefferies *et al.*, 2019). Service interactions occur between dissimilar customer and provider systems: "dissimilarity between systems raises questions about the conditions under which value co-creation aligns customers and providers, especially when cooperation with expert advice is key" (p. 422). This grows complicated when service interaction can use multiple platforms. Indeed, the authors acknowledge that "the boundary between customers and service organizations differs for face-to-face versus technologically-mediated interfaces" (p. 422) because digital interfaces change regulatory and flexibility processes. Actors' use of digital interfaces attempts to co-create value through boundary work in functional, relational and translational adaptations in healthcare (Jefferies *et al.*, 2019). Technologies used in health practice play a key role in mediating interactions.

However, scholars report finding little research on how technologies affect boundary work into value co-creation processes (Kleinaltenkamp *et al.*, 2018). Thus, it seems valuable to investigate the potential overlap between boundary work and value co-creation practices.

Research method

We adopted a qualitative research design to effectively interpret context and meanings related to human–robot interactions (Christou *et al.*, 2020). Through a grounded approach (Gioia *et al.*, 2013) we gained a contextual understanding and captured "the organizational experience in terms that are adequate at the levels of (a) meaning for the people living that experience and (b) social scientific theorizing about that experience" (p. 15).

Context of study

The study context concerns the cognitive assistant IBM Watson Health embodied in different companies' customized packages/user interfaces, and its adoption by the youngest cohort (50–64-year-olds) of the ageing population.

First, we chose IBM Watson Health as an "extreme case" (Flyvbjerg, 2006), which "reveals more information because it activates more actors and more basic mechanisms in the situation studied" (p. 229). It is extreme in the sense that IBM Watson Health is a world-leading cognitive computing technology configured to support life sciences (Chen *et al.*, 2016). Its features can be summarized under: (1) specific capabilities for analyzing high-volume healthcare data, (2) understanding complex questions posed in natural language, (3) continuous learning and (4) proposing evidence-based answers (Magistretti *et al.*, 2019). Technology drives data exploration automates predictive analytics, and easily creates dashboards and infographics. This enables answers and new insights to be found and confident decisions to be made in minutes (Russo Spena *et al.*, 2019). Using multiple clouds, it processes data in an integrated development environment so it can work with an ecosystem perspective. IBM Watson includes about 270 healthcare applications and has active users worldwide (Chen *et al.*, 2016), which helped us to collect data.

Then, we selected the middle age segment (50–64), thus addressing a gap in the literature. Most service studies concentrate on older adults (65+), who evaluate service encounters, derive satisfaction and perceived usefulness mostly according to social ties and past experiences (Grougiou and Pettigrew, 2011). Healthcare is starting to acknowledge that, to stimulate value co-creation practices, patients must maintain an active role and be closely involved (McColl-Kennedy *et al.*, 2017).

Focusing on one segment afforded data insights from a homogenous group with a common way of doing, fitting what a practice should be. We were interested in how key actors – this youngest ageing segment and their network (family, caregivers, etc.) – make sense of cognitive technologies and alter their value co-creation practices accordingly. This choice also reflects our overall interpretivist stance (McChesney and Aldridge, 2019).

Data collection

Data collection comprised two phases and involved rich data collections and analysis (Lincoln and Guba, 1985; Charmaz, 2014). In phase 1 we investigated the IBM Watson Health platform itself over six months (March–September 2019), including five preliminary interviews with members of IBM's software division. They explained the kinds of services Watson Health provides and how it supports healthcare organizations. Secondary sources that enriched our preliminary database were official documents from IBM, such as websites, archives and business publications, plus materials from key informants.

This preliminary analysis delineated a purposeful sample (Morse, 2007) of 21 health solutions that had embedded the Watson cognitive platform, and which were provided by the firms labeled A to U in Table 1. To identify the providers who would inform these case studies, we applied a judgment process (Morse, 2007) to various IBM client organizations, using as criteria an in-depth analysis of their reports, and providers' availability to participate.

In the second (and main) phase, the primary data sources were semi-structured interviews with providers of technologies, doctors, caregivers, ageing actors' relatives and ageing actors and other users of these solutions. The ageing participants ranged between 50 and 64 years and were selected from people living independently who agreed to be interviewed and who had a link with the 21 health service providers exceeding six months. We excluded people with serious cognitive or psychological problems (e.g. anxiety/depressive disorders, schizophrenia) that would have prevented us respecting ethical and privacy standards. We also interviewed people such as relatives if they managed the patients' technology solutions. Two of the researchers conducted the interviews (average duration: 45–60 min) using Webex and/or Skype. A semi-structured questionnaire helped elicit insights into how cognitive assistants based on Watson Health affected interviewees' activities, while leaving them free to raise new topics. The aim was to generate enough in-depth material to illuminate the patterns, concepts and categories of the phenomena investigated (Gummesson, 2005). Secondary data were collected from companies' internal reports and additional public documents. Triangulating qualitative research lets us evaluate phenomena from multiple perspectives and sources and more confidently grasp meanings from real contexts.

Data analysis

We coded and analyzed data from both phases following Gioia *et al.* (2013), to reach a coding structure. We first open-coded the data manually to discern initial categories from the interviews and secondary data. Rather than mechanistic reduction, coding means "taking raw data and raising it to a conceptual level" (Gummesson, 2017, p. 205). The first-order analysis tried to honor informants' wording while eliciting categories that identified Watson's features and their link to each actor's actions.

We next highlighted similarities and differences. Our data reduction and classification sought categories, overarching themes and aggregate dimensions (Gioia *et al.*, 2013). Analyzing different aspects and including more descriptions brought out distinctions, which helped us to map the dynamics of actors' interactions and learn what actions they performed. We then assigned labels or phrasal descriptors based on interviewees' actual words, which indicated common ways of doing, shared languages and similar sets of actions and tools. We identified eight categories and four themes linked to the activities and boundary work cognitive assistant enabled. By further theorizing on the coding structure (as finalized in Figure 1), we also identified two aggregate dimensions representing emerging co-creation practices. Each dimension combines different themes. Our findings use interview extracts not as simple quotes but as narratives to depict the broader role of the cognitive assistant in the eyes of ageing actors, doctors, providers, families and caregivers.

The techniques used for data collection and analysis ensured research credibility, transparency and reflexivity (Denzin and Lincoln, 1998; Verleye, 2019). We first presented the results to research participants to obtain more feedback and validate the findings, then held two meetings with actors outside our sample to get external reviewers' feedback and refine our process (Creswell *et al.*, 2007).

Findings

The IBM cognitive assistant Watson Health redefines boundaries in practices' elements, namely (1) actors (doctors, ageing people, families); (2) resources (data, information, artefacts);

Table 1. Cases investigated

Company	Roles of IBM Watson Health	Data sources	Company	Roles of IBM Watson Health	Data sources
A	To identify and flag up unusual behavior to enable caregivers to provide service and share information with relatives	2 Caregivers (1 h 30 min) 1 IT Solution Consultant (1 h)	B	To see where peers were achieving success and evaluate the system's processes against the backdrop of hard, actionable data, to improve service quality as well as to reduce costs	1 Ageing Actor (1 h 55 min) 1 Doctor (1 h 30 min) 1 IT Specialist Networking (1 h)
C	To progress toward a more robust ageing population healthcare model by adding care coordination activities and improving key process measures	1 Project Manager (45 min) N.1 Ageing Actor (1 h 50 min)	D	To help ageing actors with complex and chronic conditions such as asthma, pain, migraine, and neurodegenerative diseases	2 Ageing Actors (1 h 30 min) 1 Doctor 2 Ageing Actors' Relatives (55 min)
E	To predict the onset of dangerously low blood sugar in diabetics, often up to three hours in advance of serious medical implications	1 IT Specialist (1 h 40 min) 2 Ageing Actors (1 h 50 min) 1 Doctor	F	To match patients accurately and consistently to clinical trials for which they may be eligible, so that healthcare providers and patients can consider appropriate trials as part of a care plan	1 Ageing Actor (1 h 55 min) 1 CEO (1 h)
G	To understand medical conditions and recommend courses of action to improve care, share best practices and collaborate on clinical trials	1 doctor (1 h 20 min) 2 Ageing Actors (1 h 40 min) 1 Ageing actor's relative (1 h)	H	To advance healthcare for the ageing population	1 Caregivers (50 min) 1 CEO (1 h) 2 Ageing Actors (1 h 50 min)
I	To provide virtual coaches for ageing patients	1 CEO (1 h) 1 Digital Strategy and Ix Lead (1 h 45 min) 1 Ageing Actor (1 h 20 min)	J	To read structured and unstructured information in a cardiologist's medical reports, combine that with a variety of data and extract relevant information to support diagnosing older patients	1 Doctor (45 min) 1 Senior Vice President (1 h 30 min) 2 Ageing Actors (1 h 50 min)

(*continued*)

Table 1.

Company	Roles of IBM Watson Health	Data sources	Company	Roles of IBM Watson Health	Data sources
K	To provider care and assisted living facilities, to capture and analyze motion, location, and other data from ambient and wearable sensors	3 Ageing Actors (1 h 50 min) 1 Doctor and Director of Research Innovation and Technology (30 min)	L	To measure system-wide performance, monitoring key metrics such as length of stay, mortality, and readmissions	2 Ageing Actors (1 h 10 min) 1 Executive IT Architect (1 h 20 min)
M	To help enhance overall well-being and enable improved care at lower costs and with reduced human effort	1 Chief Health Officer (50 min) 2 Ageing Actors (1 h 45 min)	N	To allow doctors to access all study data about ageing people and platform functions through a centralized web interface	2 Doctors (1 h 50 min) 1 Deputy Health Officer (1 h)
O	To speed up emergency assistance for vulnerable actors in medical emergencies	1 Founder and CEO (1 h 10 min) 3 Ageing Actors (1 h 50 min) 1 Caregivers (1 h)	P	To create better processes to eliminate wasteful healthcare spending in the ageing context	1 Chief Health Officer (45 min) 2 Ageing Actors (1 h 45 min)
Q	To provide personalized wellness patterns tailored to each individual, and early warning notifications if something seems wrong	2 Ageing Actors (1 h 10 min) 1 Advisory Solution Consultant (50 min)	R	To identify the root of the hospital's rising readmission rate and formulate a plan to improve a patient- centric approach across the care continuum	1 Doctor (1 h 30 min) 1 Digital Manager (45 min) 2 Ageing Actors
S	To adopt an ageing population health management (EPHM) technology to automate processes and interface easily with the multiple aspects of the work	1 Founder & CEO (45 min) 1 Ageing Actors s (1 h 50 min) 1 Caregiver	T	To personalize patient care and help alleviate individual anxieties	1 Ageing Actor (1 h) 1 IT Manager (50 min) 1 Doctor (50 min) 1 Ageing actors' relative
U	To keep ageing citizens safe in their homes	1 Director of Research Innovation and Technology (1 h 25 min) 1 Ageing actor (1 h)			

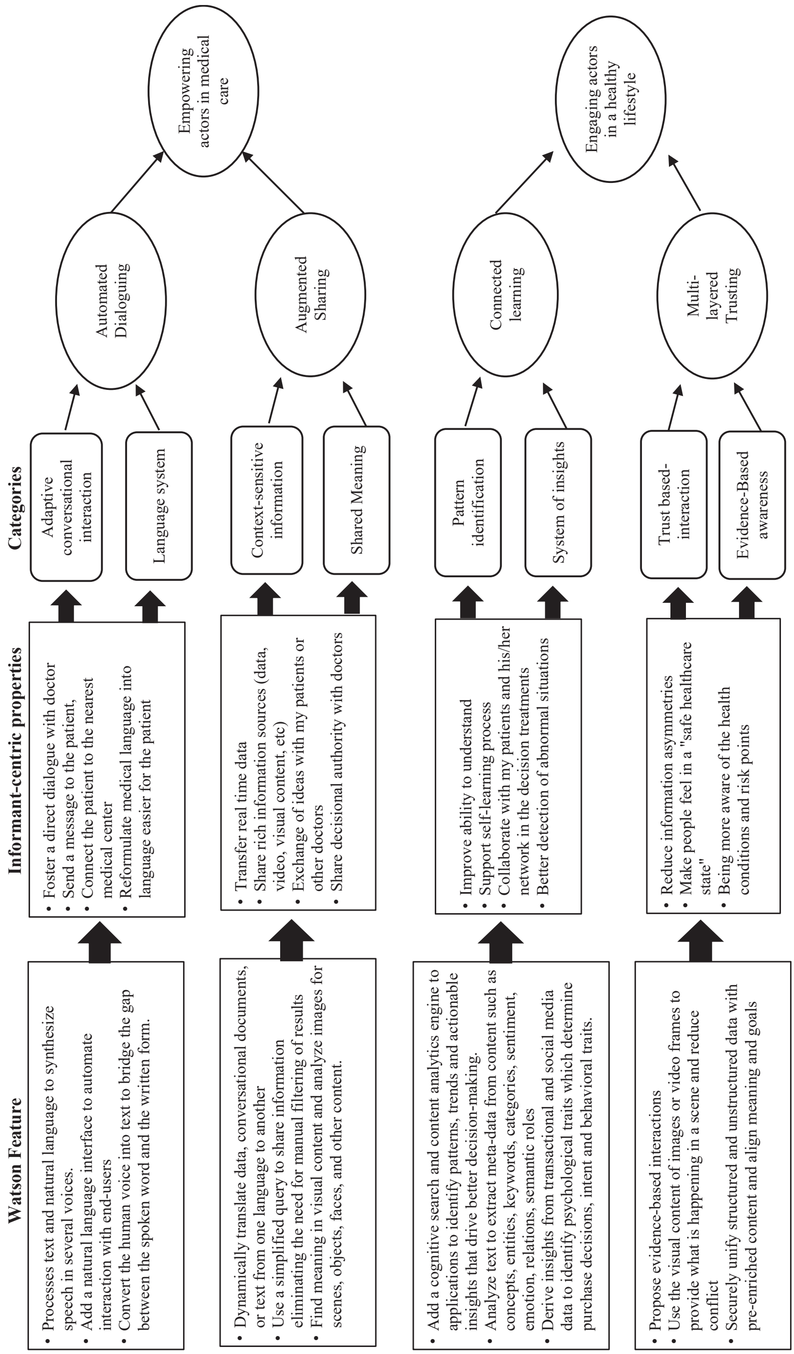

Figure 1.
Coding structure

and (3) outcomes (disease and wellness). It transforms and translates data and information and serves as a bridge by enabling actors to re-distribute responsibilities, actions and interactions on both sides of the patient–doctor relationships.

Thus, the cognitive assistant acts as a boundary object by bridging actors, resources and activities. It enacts the boundary work of actors (both ageing and professional, caregivers, families) consisting of four main actions (automated dialoguing, augmented sharing, connected learning and multilayered trusting), which elicit two value co-creation practices: empowering actors in medical care and engaging actors in a healthy lifestyle.

Automated dialoguing

IBM Watson interacts through natural language and a conversational interface. It turns medical language into patient-friendly wording. It creates opportunities for ageing actors, doctors and other caregivers to become connected and engaged in an ongoing data-based dialogue. The boundaries among different actors become blurred and are redefined. By overcoming time–space boundaries, the cognitive assistant fosters conversations when and where they are needed between patients and doctors about health conditions, therapies, daily behaviors, needs and difficulties.

> We use IBM's insight to improve communications. It holds a conversation with users in natural language in order to help them solve problems of common heuristics and biases. Indeed, it can use cognitive linguistic analysis to identify a variety of tones such as joy, sadness, anger, and agreeableness at both the sentence and document level (source: IT Solution Consultant, Company A).

> Sugar.IQ App, a diabetes application, makes me feel actively involved due to the direct dialogue with my doctors, my family, and ageing people with my similar pathologies. Everywhere at any time I know that I can ask for info from more experienced caregivers wherever, whenever it helps me manage information and improve my ability to understand the best food to stay healthy (source: Ageing Actor, Company E).

Augmented sharing

The cognitive assistant lets actors share rich and timely information, mainly data, processes, metrics, policies, and rules. Information can easily flow among the actors. Augmented sharing supports actors (patients, caregivers, families, etc.) to take control over ageing actors' care and engagement with the medical treatments. IBM Watson becomes a virtual coach for patients, tracking physiological data in real time, predicting patient outcomes, suggesting treatment plans and giving ageing people targeted encouragement during recovery. It bridges the cognitive and emotional distances in patient–physician interactions.

> In case of excessive blood sugar or different levels of insulin, MiniMed Connect sends a message to the ageing patient's healthcare providers, connects to the nearest medical center and suggests specific food- or therapy-related actions (source: Digital Strategy and Ix Lead, Company R).

> When my blood pressure is too high and the data point to worrying health situations, such as heart attacks, my app generates a direct video link with the doctor and my daughter at the same time (source: Ageing Actor, Company P).

Connected learning

Through Watson's cognitive capabilities, both the ageing and other actors learn more about how to improve patient's health conditions. The cognitive assistant supports physicians and ageing actors to understand the health indicators hidden within their data. Their learning is sustained by ongoing interactions. The moment Watson detects an abnormality and alerts doctors, they can decide how to respond. Connected learning prompts the actors to generate new data, information and knowledge. This disperses valuable know-how as actors bridge and connect their respective knowledge and expertise – to their evident satisfaction.

> My dad loves his cognitive hospital app and so do I! I love monitoring his vital parameters. Having an allergic crisis is very difficult, but this app has helped our family feel better about detecting and alerting doctors when he has one. Moreover, the ability to enter one's daily vital signs and share them with doctors lets you learn the health indicators hidden in the data (source: Ageing actor's relative, Company G).

> The cognitive assistant is of fundamental importance to help us work properly. The caregiver's ability to learn why our patient has reacted badly to a therapy in the past, by linking directly to past experiences, allows us to better predict the treatments we would like the patient to undergo (source: Founder & CEO, Company S).

Multilayered trusting

IBM Watson generally brings many actors together in seeking an inclusive viewpoint in their interactions, valuing and accommodating potentially conflicting perspectives, and unmasking assumptions and discrepancies in treatments. This reduces information asymmetry and builds trust in relationships, actions and meanings. By monitoring data in real time, cognitive technologies support physicians, caregivers and ageing actors to assess decisions together and trust each other in their care context. Through this boundary work the high-quality health information and ongoing interactions alleviated ageing patients' sense of vulnerability, fear of opportunistic behavior and general risk.

> Dedicating only a few moments of the day to the patients and not being with them for 12 or 24 hours, makes them feel alone and fragile. The feeling of loneliness leads to insecurity, and they no longer trust us. So, we decided to assist them with cognitive technologies 24 hours a day. The patient begins to trust in the suggestions and personalized solutions offered by their technological assistant. The longer the patient spends with it, the more confidence increases (source: IT Specialist Networking, Company B).

> When the disease hit me, and I moved to the hospital, I found myself in a new and unknown world. I had a double fear of both the disease that was progressing and the fear of having to live in that environment, away from the care of my loved ones. So, when I was introduced to my personal cognitive assistant, I did not know what to do and felt even more abandoned. Everything changed when I started to try out what it could do. The constant control of my state of health, and voice updates, give me trust. Its voice reassures me (source: Ageing actor, Company B).

Value co-creation practices

Cognitive assistants enact actors' boundary work by supporting the way they share and integrate resources and yield different ways to perform activities. Cognition about what illness and wellness mean and can be enacted are transformed in the healthcare ecosystem.

Through cognitive assistance actors develop boundary work by making previous physical and cognitive boundaries both visible and open for discussion and collaboration, contributing to the inscription of new roles, meanings and interfaces that become materialized into new value co-creation practices. Two enhanced value co-creation practices emerge not simply as the result of a human-technology interaction; rather, they come from the specific actions described above and result in widening interrelations, increasing resource integration and impact on the specific needs, languages and situations of ageing actors.

The first practice, empowering actors in medical care, relates to the actors themselves wanting to maximize self-determination and independence despite an unhealthy condition. Patients and their networks expect to be involved in decisions about their care. When patients or families know they are connected to the nearest doctor or medical center and can exchange informed messages with them, they interact more readily. Automated dialoguing allows patients and doctors to overcome physical and language boundaries and boost their interactions in a specific situational context.

> Mabu keeps me alert about remembering to take my medicine. It asks if I've had any shortness of breath and other questions pertaining to my health. With my cognitive assistant, I feel more protected and due to the ready feedback. I can better focus on my therapy. It keeps me aware of my disease and builds my self-treatment. In addition, I know that I am always connected with my doctors and my caregivers, and this allows me to feel less vulnerable and easily interpret health stressed situations and how to manage (source: Ageing actor, Company U).

Better care requires aligning a broad-based data analysis with appropriate and timely decisions, and predictive analytics that support clinical decision-making by prioritizing ageing actors' situational contexts and actions. By augmented sharing, doctors can acquire and exchange information faster and in depth, by unlocking copious health data through patient interactions, and patients can feel more confident of diagnosis. Health decisions become evidence-based and free of cognitive biases, enabling rapid analysis, reducing misdiagnosis and inspiring patient confidence. With this technology, actors transform their respective knowledge into a common sharing where, vitally, doctors and patients see a general picture of patients' health. This augmented sharing promotes patients' autonomy and encourages not only patients' control over their care but concomitantly their engagement with the treatments.

> Using IBM Watson creates a win-win situation for my patients and me as a doctor and care manager. In my experience patients often hesitate to share health information with their healthcare providers. The technology helps me easily determine how my patients manage their chronic disease and become more acquainted with their current health status and the important steps in their care. Most importantly, patients do not fall through the cracks like they might have in the past with our manual processes. They are more aware of their conditions and get the continual follow-up they need (source: Doctor and Director of Research Innovation and Technology, Company K).

The second practice, engaging actors in a healthy lifestyle, means not only to support patients and their network in following treatment recommendations but to keep patients active and healthy into prospect age – that is, to keep them well. Notably, this can apply to ageing actors who are not necessarily sick or in need of specific care but who want to maximize their health status. In our study, 50–64-year-old patients became able to better manage their health by transforming data into information to put them in a self-control of their health. One of the cognitive assistant's biggest potential benefits is to help people stay healthy so they have no need of a doctor, or at least not as often. In addition, it helps professionals understand their patients' day-to-day patterns and needs and gives them better feedback, guidance and support for staying healthy. Patients and their network feel better informed about good health practices and become more likely to manage their daily lives without sacrificing safety or health-promoting behavior. The connected learning experienced by the actors resulted in expanded opportunities for ongoing improvements in ageing with a healthy lifestyle. When the cognitive assistant channels the systemic insights into both the doctors' or caregiver's knowledge workflow and the ageing person's daily routine, health assurance is dramatically boosted.

> The ability to learn how many calories I eat daily and obtain advice based on the monitoring and continuous tracking of my eating habits allows me to keep myself healthy. Before using HAPIfork, I did not have the ability to control the daily calories and the right proteins to consume. Now it's different! I have a connection with my personal caregivers, I can instantly see if that food is compromising my health and make the right food choice based on data and information (Source: Ageing actor, Company T).

Health status while ageing is also enhanced by the power (whether alone or supported by others) to trust in exploring alternative choices, integrating new information and to seek new congruence in one's health decision-making. Cognitive assistants allow actors to resolve ambiguity and incompleteness and build new trust based on data that sense the patient's intent, or requirement. A new awareness grows on day-to-day evidence-based interaction that the cognitive assistant allows, when it is used to influence decisions on the most appropriate health arrangement for the actors. Through multilayered trust, the ageing actors engage better with healthy lifestyle advice and are encouraged toward proactive self-health management. Engaging in a healthy status is about data-based trust prompted by an ageing actor in interactions with his or her network to be more confident over his/her lifestyle.

> My tech-assistant offers me a source of companionship, while encouraging me to reach my health and wellness goals. It interacts with me, offering me tips and advices, that help me to manage information and communicate easily with my caregivers to improve care (source: Ageing actor, Company U)

Discussion

This work centered on a key research priority in service science: how to foster value co-creation practices in healthcare through technologies (Kabadayi *et al.*, 2020; Ostrom *et al.*, 2021). Our study addresses the gap in literature on the youngest cohort of the new Silver Economy "ageing" population: the 50–64-year-old segment. We offer a fresh understanding on the role of cognitive assistants as boundary objects enabling the boundary work of actors for value co-creation. In the ageing context the mediating role of the cognitive assistant arises: it bridges actors' views, interactions, resource exchange and integration. Artefacts and objects matter in service provision, so warrant more research. Recent technology-based service studies have focused more on service-robot interactions as human-like interactions (Čaić *et al.*, 2018; Odekerken-Schröder *et al.*, 2020) and have marginalized objects at the very time when their importance has grown (Mele *et al.*, 2019). A cognitive assistant acts as a boundary object by enabling that certain activities of multiple actors are brought together, by orienting interactions and the integration of resources. Specifically, cognitive assistant is an "object of activity" (Macpherson *et al.*, 2006; Nicolini *et al.*, 2012) that mediates in actors' boundary work by: (1) providing a drive for wider interactions, (2) offering novel resource interfaces and (3) allowing multiple actors' perspectives to be aligned through different types of cognitive and physical boundaries. Actors' boundary work deploys through four main mediated technology actions: database dialoguing, augmented sharing, connected learning, multilayered trusting. First, automated dialoguing relates to interacting actors (doctors, ageing actors and others) communicating about the situation, within certain parameters. By analyzing data in real time, through dialogue, ageing actors can evaluate their health issues. Second, augmented sharing concerns patient-centered care, patient and other actors' engagement and informed-based choices (McColl Kennedy *et al.*, 2012): a collaborative endeavor where physicians and patients to share information, intuitions and meanings. Dialoguing and sharing encourage decisions about healthful behaviors, boosting actors' confidence in their ability to control health status. Third, connected learning prompts actors to generate new data, information and knowledge and focuses attention on concrete absorbing in actions and interactions while multilayered trust supports actors in the wider arrangements involving multiple insights and values. Learning and trust align actors' knowledge perceptions, expectations and supporting the improvement of the ageing actors' lifestyles.

The analysis of the actors' boundary work allows us to disentangle the process of value creation between actors within the healthcare context. Through the four actions, actors can overcome cognitive and physical boundaries and increase access to new knowledge and capabilities, thus increasing resourceness. Wider resource access and resourceness foster resource integration and matching as the main mechanism of value co-creation (Gummesson and Mele, 2010; Vargo and Lusch, 2014). Two enhanced value co-creation practices emerge:

empowering actors in medical care and engaging them in a healthy lifestyle. Ageing actors rely on a decision-making process that integrates resources, directs actions and orients interactions, consistent with their present and prospective capabilities and needs; as well as the support of doctors, caregivers and families to improve patient's care. We extend the scope of value co-creation practices beyond the focus on treating illness and take into account patients (ageing actors) themselves and their network and consider healthy status being more holistically and positively (McColl-Kennedy *et al.*, 2017; Frow *et al.*, 2016). Service scholars have pointed to features of cognitive technologies and their roles (Odekerken-Schröder *et al.*, 2020) related to value co-creation (Kaartemo and Helkkula, 2018). We trace how this process unfolds by linking technology features to actors' practices. By overcoming boundaries, actors enact language, meaning, knowledge and trust to enhance contextual resource integration. They comprehend the day-to-day patterns of their condition and their needs, and thus are able to supply better feedback, which in turn enhances professionals' guidance and their support for staying healthy. Through the cognitive assistant, actors see data and information transformed into actions to create new capabilities, richer experiences and necessary context for their care and/or healthy status beyond illness (Keyes *et al.*, 2014).

In sum, the boundary work of actors enacted by cognitive assistants support a smarter resource integration that yields broader applications for augmented agency (Mele *et al.*, 2021). Similarly, to Barad (2003) and Latour (2005) we argue that an enhanced agency emerges at the encounter between humans, artefacts, texts and discourses crossing expertise and contextual boundaries. Value co-creation articulated in a cognitive-assisted health context, as defined here, is intensified and enacted by integration of data and capabilities that expand ageing actors' health status. Thus, actors' capacity to maintain health is not something stable that only an actor holds, or only a machine can enhance; agency to attain any health status emerges from the encounter and "intra-action" (Barad, 2003) between informed humans (doctors plus patients, their networks and other health professionals) and technologies. Moreover, characterizing the human agent as the head and the rest as having complementary status, as service technologies literature does, strikes us as problematic. Applying the study of boundary work to technologies may, we suggest, initiate subtler thinking about the growing role of materiality in service research.

Implications for practitioners

The twenty-first century goal of successful ageing requires consideration not only of illness status, such as minimizing disease and disability, but also wellness status. Cognitive assistants can lighten the burden of health tasks and help people age actively and successfully, with independence and high quality of life. Accordingly, we claim that activities within value co-creation practices comprehend, for instance, discussing data with patients, sharing the task of diagnosis, learning in action about treatment options and cultivating trust in specific therapies and ways of staying healthy. We believe that cognitive assistants enable actors to increase value co-creation by improving their access to, and ability to interact with, actionable resources (data, information, languages). The actors' boundary work is supported by expanding expertise into health domains and enhanced value co-creation practices can emerge in the technology-based health services. Specific implications arise for professionals (doctors and caregivers) and for technology providers.

First, professionals (medical and other caregivers) need to appreciate cognitive applications as boundary objects. This potentiality includes the ability to collect and integrate different information (medical, scientific, daily patients' routine, etc.), to improve patients' health status, to transform roles of both patients and caregivers by bridging distances and constraints and to reduce data asymmetries and knowledge gaps. Doctors and caregivers can leverage the boundary work that the cognitive assistants enhance by promoting dialoguing, sharing, learning and trusting. These actions not only provide opportunities to establish new linkages and to manage interactions among different parties but mobilize a transformation in the way new resources can be generated and resource integration and matching can take place.

Professionals may combine extensive disease expertise with the deep analytical capabilities of assistive agents to personalize insights and tailor care plans. In this approach, they need to share languages and plans to promote healthful behaviors, giving patients the confidence to manage their own care and alter or modify their lifestyles in a health-promoting way through connections with other actors providing valuable know-how, thus enabling patients and caregivers to gain a sense of healthcare confidence, trust and comfort. By promoting new ways of interacting through cognitive assistants, professionals need to become sure of how to manipulate the patterns of resource integration among groups of actors to ensure that certain activities are brought together, orienting the domains of collaboration for patients' healthcare status.

Second, technology providers hold a key role in supporting actors' boundary work. New tech-based solutions can be pivotal in enhancing active and healthy ageing co-creation practices. Cognitive technologies are potential parts of the cognitive humanist's toolkit and their role as boundary objects needs to be deepened with regards to how to better stimulate or facilitate communication and coordination by eradicating possible points of confusion or conflict and transforming them into valuable assets in linking resources and activities. For example, as a matter of equity as well as efficiency, managers should appreciate how major digital and health inequalities among ageing actors will influence the provision of accessible, equitable, secure and context-appropriate information. Introducing cognitive assistants has required that actors without previous shared practices negotiate and integrate into their everyday work not only new technologies and material arrangements, but also each other's established practices. As we found, health technology solutions for ageing can enable different practices, but success may depend on doctors and caregivers taking active roles in promoting new practices in the use of technologies, and patients being engaged, too. Capturing and harnessing this growth market will demand that managers grasp the complex and diverse needs of ageing actors.

Limitations and further research

This paper has some limitations that could serve to guide further research into cognitive technology and value co-creation.

First, the study focuses on one single cognitive assistant. Further research could collect data from multiple cognitive assistants to properly validate or improve the results obtained in this study. Specific research questions guide theoretical conceptualization to advance the debate of cognitive assistants as boundary objects and boundary work in service research:

(1) How could a typology of cognitive assistants as boundary objects be developed?

(2) How does the investigation of cognitive technologies allow scholars to understand boundaries between and within groups of actors, and how to overcome such demarcations?

(3) What are the antecedents and the moderators in the actors' boundary work related to technology adoption?

(4) How to derive a boundary work theory related to resource integration and value co-creation?

Second, the challenges and obstacles in resource integration affecting value co-creation are not investigated. This paper acknowledges that cognitive technologies not only consist of physical or technical features or attributes but reflect the new languages, actions, meanings and values that become embedded with the real context of technology-in-use and actors' interactions. Healthcare outcomes depend not only on access (McColl-Kennedy *et al.*, 2012, 2017) but on how multiple actors integrate resources relating to the informed activities they undertake, their interactions in the service network and the trust they develop concerning resource integration processes. This calls for much more debate on the design of technologies in supporting actors' boundary work, as they participate (or do not) in steering the resource integration. Further research questions may lead the conceptualization of resource integration, actors' agency and value co-creation in the emerging technology-enhanced service context:

(1) How can the design of boundary objects enable or constrain the actors' agency?

(2) How can physical, cognitive and ethical barriers limit the actors' boundary work?

(3) How can the design of boundary objects reduce the effects of physical, cognitive and ethical barriers in value co-creation practices?

(4) Could physical or cognitive features of boundary objects affect actors' boundary work in different ways?

Finally, our study's impact analysis considers only certain aspects of the Silver Economy, namely healthcare services. But with their purchasing power (the famous "silver dollar"), standard of living and education, the prospective segment are fast becoming desirable and valued consumers for diverse sectors, especially those related to leisure (culture and recreation) (Kubiak, 2016) or smart homes (Čaić *et al.*, 2018). This being a cross-section market, further studies can take the analysis of co-creation practices onward into fresh technology-based service contexts. Further questions should muster evidence on different actors co-cocreation practices.

(1) How can imbued service technology address the needs of ageing actors in different service contexts?

(2) What are the implications of tech literacy (for ageing populations) as boundaries for value co-creation in tech-based healthcare?

(3) How can technology-mediated boundary work of actors break down the old stereotypes and roles of ageing people in society?

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